PROJECT TITLE: Circulation in the Vicinity of Descending Overflows

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LONG TERM GOALS

The long-term goal of this project is to contribute to our understanding of the circulation, exchange, and environment between marginal seas and the open ocean.

OBJECTIVE

To better understand the mean and time-dependent circulations induced in the upper ocean by turbulent entrainment in the vicinity of steep bottom topography.

APPROACH

Idealized numerical modelling studies are used in conjunction with theory to better understand the large scale circulations that are forced by entrainment into mixing regions. The results are interpreted and understood by making use of potential vorticity budgets, integral constraints, and thermodynamic balances. Geometries under study include: entrainment in the open ocean, entrainment near steep topography, and entrainment near ridges and seamounts.

WORK COMPLETED

Simple theoretical estimates of downwelling rates supported by three different processes (mixing near topography, baroclinic instability, and open ocean sinking) have been derived. A series of general circulation modelling studies has been carried out and compared to theory for these various sinking mechanisms in an idealized subpolar gyre.

An isopycnal model has been configured to study the large scale circulation induced by localized diapycnal mixing in simply and multiply connected domains. Fundamental integral constraints have been developed to interpret the resulting circulation patterns and transports.

RESULTS

Theoretical and numerical modelling results have shown that a dominant component of the downwelling limb of the thermohaline circulation takes place where diapycnal mixing is found near steep topography, such as is found near overflows and cyclonic rim currents. Because of these dynamics, the sea surface temperature, horizontal circulation, and overturning circulation in a subpolar gyre are very sensitive to the degree of mixing experienced along the perimeter of the basin (Fig. 1). It has also been shown that localized diapycnal mixing near islands and/or ridges can force strong mean flows far from the region of mixing, including on the opposite side of the topography, in general agreement with theory.

IMPACT/APPLICATIONS

These results indicate that the near coastal region, and in particular the boundary current systems, are of first order importance to the large scale circulation and sea surface temperature. Mixing near topography can force circulations far from the region of mixing. Reliable observations and parameterizations of such diapycnal mixing processes are required to properly represent the large scale circulation in general circulation models.

PUBLICATIONS

Spall, M. A. and R. S. Pickart, 1999. Where does dense water sink? A subpolar gyre example. submitted to: J. Phys. Oceanogr.

Spall, M. A., 1999. Large scale circulations forced by diapycnal mixing near topography. manuscript in preparation.

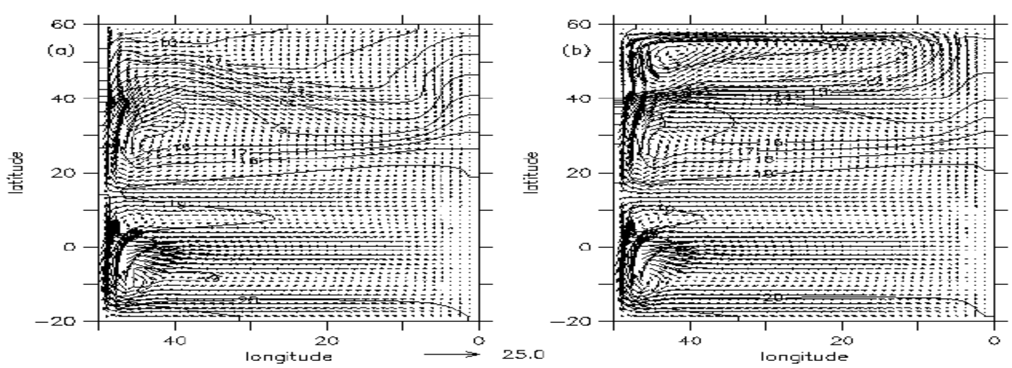

Figure 1: Horizontal velocity and temperature at 38.5m depth for a wind- and buoyancy driven basin scale model. With a flat bottom (a), there is no evidence of the cyclonic wind-driven subpolar gyre (the cyclonic flow is deep), the western subpolar basin is relatively warm, and the boundary current separates from the western boundary in a broad, eastward flow. With a continental shelf (b), the subpolar gyre exhibits a strong cyclonic upper ocean rim current, a cold western subpolar gyre, and a sharper separated boundary current. These large differences are due to the decrease in convective mixing near the basin perimeter and the resulting reduction in the high latitude overturning circulation.